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CFRP Strengthening of RC tensile members with stiff and soft adhesives

Roman Sedlmair, Lothar Stempniewski

Karlsruhe Institute of Technology, Karlsruhe, Germany

Contacting author: roman.sedlmair@kit.edu

Abstract

Single lap shear tests with externally bonded carbon fibre reinforced polymers (CFRP) laminates are carried out to examine the effect of differing adhesives on the load-slip behaviour. Displacement of the surface are measured with digital image correlation (DIC) to establish the cohesive material response for the interface. Due to the changed material properties (softer adhesive) larger effective bond lengths (from the textile to concrete) are examined. The determined cohesive laws are implemented in a numerical simulation of externally strengthened reinforced concrete (RC) tensile members to show the potential usability of softer adhesives for the strengthening technique. A change in the overall behaviour of strengthened systems and a more compatible system (plain strain distribution) could be in sight.

Keywords: Assessment/Repair; Rehabilitation; FRP; soft adhesive; bond behaviour; interaction.

1. Introduction

Since the 1960s, applications of post-strengthening of reinforced concrete (RC) with externally bonded reinforcement (EBR), nowadays mostly carbon fibre reinforced polymers (CFRP), are constantly increasing. Due to the different bond behaviours of embedded rebars and EBR, special design approaches are necessary. A well-known problem is the brittle bond behaviour of the EBR which contrasts with the ductile bond behaviour of embedded reinforcement resulting in an uneven strain and force distribution. These points lead to significant limitations for practical use and there is still a lack of information about the usability of adhesives beside the often used epoxy resins.

Some authors reported about positive change in the overall behaviour of CFRP-strengthened beams with softer adhesives or soften epoxy resins owing to elevated temperatures. [1, 2] Therefore experimental and numerical investigations were executed.

The present paper focuses on two subjects: (a) single lap shear tests with externally bonded CFRPs to determine the local bond-stress slip laws and the modification of the bond behaviour due to the use of differing adhesives and (b) on numerical analyses using the ABAQUS finite element program to take a closer look at the interaction of embedded and EBR. Tensile RC members strengthened with CFRP on two sides of the concrete blocks are simulated. The nonlinear material behaviour of concrete is taken into account using appropriate constitutive models; CFRP is treated as a linear elastic material. Bond-slip relationships are used to define the interface laws of CFRP to concrete and steel bars to concrete. Cracking of concrete is taken into account by modelling with a discrete crack approach. Experimental results from the author and from literature are used to verify the numerical model.

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